

SECTION 15898
STAINLESS-STEEL DUCTWORK AND ACCESSORIES-ALL WELDED
(CERTIFIED MATERIALS)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions apply to this Section.

1.2 SUMMARY

- A. This section includes: General requirements for the fabrication and installation of Stainless Steel ductwork and accessories having all welded seams and joints for operation at static pressure not to exceed 20 inches of WG (4,976 Pa) positive or negative, and at any velocity for the Beam Dump Confinement Exhaust (BDCE) System.
- B. Ductwork and accessories for this system are classified as High Hazard and designed to operate within a pressure range of minus 2 inches to minus 15 inches WG (498 to 3,732 Pa) and may be constructed as rectangular or round. Exhaust system elements include:
 - 1. Exhaust ductwork
 - 2. Back-Draft Dampers for the Beam Dump Confinement Exhaust (BDCE) systems
 - 3. Accessories are follows: Balancing or Isolation Valves / Dampers, Exhaust Grilles and Registers
- C. Related Sections include the following:
 - 1. Division 15, Section 15990, "Testing, Adjusting, and Balancing.
 - 2. Division 18, Section 18100, "General Welding Requirements".

1.3 REFERENCES

- A. American National Standards Institute (ANSI) and The American Society of Mechanical Engineers (ASME).
 - 1. ANSI/ASME N509-89, Nuclear Power Plant Air-Cleaning Units and Components.
 - 2. ASME N510-89, Testing of Nuclear Air-Cleaning Systems.
- B. American Society for Testing and Materials (ASTM).
 - 1. ASTM A240-94, Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels.
 - 2. ASTM A262-93, Rev. A, Standard Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steel.
 - 3. ASTM 276-94, Standard Specification for Stainless and Heat-Resisting Steel Bars and Shapes.
 - 4. ASTM D1056-91, Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber.
- C. American Welding Society (AWS).
 - 1. AWS A5.01-93, Filler Metal Procurement Guidelines.
- D. Engineering Standards (ES).
 - 1. ES-5.11-2, Instruments Test Ports – Welded Rectangular Duct.
 - 2. ES-5.11-6, Instruments Test Ports – Welded Round Duct.
- E. National Fire Protection Association (NFPA).

1. NFPA 90A-93, Standard for the Installation of Air Conditioning and Ventilating Systems.
- F. Sheet Metal and Air Conditioning Contractors National Association (SMANCA).
 1. SMACNA, HVAC Duct Construction Standards - Metal and Flexible, 1985.
 2. SMACNA, HVAC Air Duct Leakage Test Manual, 1985.
 3. SMACNA, Rectangular Industrial Duct Construction Standards, 1980.
 4. SMACNA, Round Industrial Duct Construction Standards, 1977.

1.4 DEFINITIONS

- A. High Hazard: Those hazards with the potential for on-site or off-site impacts to a large number of persons or for a major impact to the environment.

1.5 SUBMITTALS

- A. Submit the following for approval.
 1. Certified Test Reports for Pressure boundary materials.
 2. ASTM A262, Specimen Selection Procedure and Laboratory Results.
 3. Material Identification (mill certified).
 4. Material Traceability procedure.
- B. Submit the following Test and Inspection Reports for information.
 1. A leak test report summary, prior to concealment of ductwork.
 2. Certified Test Reports for Pressure boundary materials.
- C. Submit the following for information.
 1. Redlined, as-built drawings.
 2. Traceability documents.
 3. Leakage test procedures prior to leak testing.

1.7 SCHEDULING

- A. Notify Construction Manager (CM) prior to the actual fabrication start date. The CM will have the option to inspect prior to, during, and upon completion of fabrication and installation and witness test and inspections.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Stainless steel sheets, plates, and shapes that are pressure boundary materials: Mill certified, Type 304L Stainless Steel, and have a maximum carbon content of 0.030% ladle analysis. Sheet material to be stainless steel in accordance with ASTM A240, with 2B finish. Structural shapes to be in accordance with ASTM A276.
- B. Use 308L Stainless Steel welding filler materials with Certified Material Test Reports with a minimum of Schedule H level of testing and Lot Classification Class S3 in accordance with AWS A5.01.
- C. Fasteners such as bolts and nuts: Series 300 stainless steel.
- D. Flexible connection material: "Hypalon"-coated fiberglass fabric and be UL listed and NFPA 90A approved as noncombustible fabric and fire-retardant coating and resistant to air and water penetration, ozone, alkalis, acids, gasoline, grease, and abrasion.

- E. BDCE areas are classified as "Non-corrosive" environment: Material used shall weigh no less than 24 oz./yd² and be Ventlon (chlorosulfurated polyethylene) by Ventfabrics, Inc., or "Durolon" by Duro Dyne Corporation.
- F. Gaskets for flanged connections: 1/4 in. thick, full face, closed cell polychloroprene, (ASTM D1056, Grade SCE-43) or "Silicon".

2.2 FABRICATION

- A. Verify materials are of the type specified and welded stainless steel sheets, plates, and shapes that are pressure boundary material are mill certified.
- B. Fabricate ductwork system(s) to engineered safety feature unit, Leakage Class I of ANSI/ASME N509.
- C. Rectangular Ductwork:
 - 1. Sheet metal gages and structural angle sizes used for fabrication and reinforcement of the ductwork for both positive pressure and negative pressure duct systems are to be sized and positioned in accordance with Table 15898-1 of this specification for the pressure class shown on the drawings. Weld the reinforcement angles to the duct by equally spaced 1-in.-long fillet welds on 12-in. centers (max), staggered on alternate sides of the angle, and on both sides of the angle at each end. Weld leg size to be at least equal to the sheet metal thickness. Reinforcement around the perimeter of the rectangular duct to be made continuous by lapping and welding together the reinforcing angles at each corner.
 - 2. Fabricate duct and fittings with continuous butt-welded joints and seams. Fillet-welded seams are allowed at corners only.
 - 3. Duct butt-welded joints or seams or fillet-welded corner joints or seams do not qualify as duct reinforcement or stiffeners.
 - 4. Duct radius elbows to have a minimum inside turning radius equal to the duct dimension in the direction of turn. Splitters, where required, to be the same type material as the duct and as shown on the drawings and welded to the duct.
 - 5. Unequal, square elbows shall not be used, unless otherwise detailed on the drawings. Where indicated on the drawings, fabricate 90 degrees equal square elbows with turning vanes. Provide single thickness turning vanes without trailing edges in accordance with Fig. 2-3 of the SMACNA, HVAC Duct Construction Standards - Metal and Flexible. Fabricate vanes and runners of the same material and gage as the ductwork. Weld vanes to runners and runners to duct to prevent vibration or fluttering. Welds to be continuous. Install vanes within the elbow to project tangents to the airflow.
 - 6. Install Instrument Test Ports in accordance with ES-5.11-2 in ductwork.
- D. Round Ductwork:
 - 1. Round duct may be either purchased tubing or shop fabricated. Seams and joints to be continuous butt-welded.
 - 2. The sheet metal gages and reinforcement requirements to be used in fabricating the ductwork for positive pressure systems as follows:

<u>Diameter</u> <u>in.</u>	<u>Gage</u>	<u>Stiffener</u> <u>size, in.</u>	<u>Stiffener</u> <u>spacing, ft</u>	<u>Number of</u> <u>welds</u>
Up to 12	14	Not required	Not required	Not required
13-36	14	1 1/4 X 1 1/4 X 3/16	14	12
37-48	12	1 1/2 X 1 1/2 X 3/16	14	14
49-60	10	2 X 2 X 3/16	14	18

3. Sheet metal gages and structural angles used for fabrication and reinforcement of the round ductwork for negative pressure duct systems are to be sized and positioned in accordance with Table 15898-2 of this specification for the pressure class shown on the drawings. Weld the reinforcement angles to the duct by 1-inch-long fillet welds equally spaced and staggered on alternate sides of the angle. Weld leg size to be at least equal to the sheet metal thickness. The number of welds required on each stiffener-angle shall be as indicated on Table 15898-2. The round duct reinforcement angles to be rolled to the nominal duct diameter and be made continuous by butt-welding together the angle ends.
 4. Round ductwork elbows to have a minimum inside turning radius equal to the duct diameter and be either die stamped with butt-welded seams or gored with butt-welded joints and seams. Fabricated 72-degree to 90-degree gored elbows to have five gores; 37-degree to 71-degree elbows to have three gores; 0-degree to 36-degree elbows to have two gores.
 5. Round duct fittings to have butt-welded joints and seams. Tee connections to be of the conical type.
 6. Install instrument test ports in accordance with ES-5.11-6.
- E. Back-draft dampers: are to meet as an engineered safety feature unit.
1. Back-Draft Damper Construction Classification shall be as per Table 15898-3 labeled as Class B dampers and shall be industrial quality construction. All parts, including frame, blades, pivots, shafts, bearings and operators (if applicable) shall be designed to the above minimum criteria defined in Table 15898-3.
 2. Maximum permissible Air-Leakage rate for Class B dampers shall be as defined in Table 15898-4. in accordance with AMCA 500.
 3. Back-draft Dampers shall bear the AMCA Certification Seal.
 4. Back-draft Damper design requirements shall include:
 - a. Frame. Frames shall be rolled, formed, or fabricated into a channel shape having a minimum width of 4 in., minimum flange height of 1 1/2 in. and a minimum thickness of 1/8 in. Frame deflection under design loadings shall not exceed 1/360 of the span in any direction. Duct mounted dampers shall have pre-drilled mounting flanges, and shall be designed for mountings between flange sections of ductwork.
 - b. Blade and shaft: Blade edge and shaft deflection shall not exceed 1/360 of span or 1/8 in., whichever is less, under the forces produced by operation of the damper at 1.5 times the design conditions for floe and pressure, and shall not cause the leakage criteria to be exceeded. Shafts shall be solid and extend the full blade length with minimum diameter of 3/4 in., except dampers smaller than 19 in. by 19 in. may be designed with minimum shaft diameter of 1/2 in. Blades shall be welded or through bolted to the shaft in such manner that the integrity of the attachment can be verified. Minimum blade thickness shall be 16 gage (0.059 in.) and 18 gage (0.047 in.) for single and double thickness steel blades, respectively. Blade and edge seals shall be radiation and corrosion resistant.
 - c. Linkage: Linkage shall be located outside of the air stream, and component design shall include at least the following minimum requirements.
 - d. Brackets, arms, and levers shall be of sufficient length and stiffness to provide stable operation of the damper blades without flutter or binding, at all blade positions.
 - e. The Linkage system shall be designed to deliver sufficient torque to each blade to properly set the seals of each and every blade.
 - f. All linkage components shall be designed to transmit the required torque without exceeding the maximum stresses allowed. The required torque shall be defined as twice the portion of the damper torque the component is expected to transmit or the maximum actuator torque capability when the component may be required to transmit the full torque capability of the actuator.

- g. Bearings: Bearings shall be flange mounted, lubricant impregnated, sintered bronze type or rolling element type for temperatures of 200 °F or less. Dampers that must be operable in temperatures exceeding 200 °F shall have rolling element type bearings. All rolling element bearings shall be provided with grease fitting for lubrication. Bearings for vertically oriented blades shall be designed for thrust loads.
 - h. Fabricate Back-draft damper and fittings with continuous butt-welded joints and seams. Fillet-welded seams are allowed at corners only.
- F. Round Dampers in or out of ductwork:
1. Round Back-draft Dampers may be either purchased or shop fabricated. Seams and joints to be continuous butt-welded.
 2. The sheet metal gages and reinforcement requirements to be used in fabricating the dampers for positive pressure systems as follows:

TABLE 15898-3
DAMPER CLASSIFICATION FOR CONSTRUCTION
AND LEAKAGE

Function of Damper	Construction Class	Leakage Class
Back-draft prevention		
a. Contaminated air stream	B	II
b. Non-contaminated Air stream	B	II
Pressure relief	B	II

TABLE 15898-4
MAXIMUM PERMISSIBLE DAMPER LEAK RATE
CLASS II

Damper Blade Length, inches	Maximum Permissible Leak Rate (scfm / sq.ft of Damper Face Area, at 1 in, WG Differential pressure)
Up to 12	15
24	10
36	8
48	8

3. Sheet metal gages and structural angles used for fabrication and reinforcement of the round dampers in ductwork for negative pressure systems are to be sized and positioned in accordance with Table 15898-2 of this specification for the pressure class shown on the drawings. Weld the reinforcement angles to the damper by 1-inch-long fillet welds equally spaced and staggered on alternate sides of the angle. Weld-leg size to be at least equal to the sheet metal thickness. The round damper reinforcement angles to be rolled to the nominal duct diameter and be made continuous by butt-welding together the angle ends.
 4. Round Back-draft Damper fittings to have butt-welded joints and seams. Tee connections to be of the conical type.
 5. Install instrument test ports in accordance with ES-5.11-6.
- G. Off-site welding activities are to be in accordance with Division 18, Section 18100, and "General Welding Requirements".

2.3 SOURCE QUALITY CONTROL

- A. Stainless Steel sheets, plates that are pressure boundary materials to be tested in accordance with ASTM A262 as follows:
 - 1. Test a minimum of two random specimens from each material lot. Obtain approval on the procedure for specimen selection prior to taking specimens.
 - 2. Heat-treat each specimen for 1 hour at $1,225^{\circ}\text{F} \pm 25^{\circ}\text{F}$.
 - 3. Then subject each specimen to the oxalic acid etch test (ASTM A262, Practice A). A "step" etch structure classification (as defined in ASTM A262) is required to pass this test. Specimens, which pass this test, qualify the lot from which they are taken. For lots with specimens failing this test, subject specimens to the nitric-acid weight loss test (ASTM A262, Practice C).
 - 4. The nitric-acid test (ASTM A262, Practice C) to consist of subjecting a specimen (previously heated 1 hour at $1,225^{\circ}\text{F} \pm 25^{\circ}\text{F}$) to five 48 hours boiling periods. The average corrosion rate for the five periods is not to exceed 0.002 inches/month. In addition to the average corrosion rate, the corrosion rate for each individual period is also to be reported. Specimens, which pass this test, shall qualify the material lot. Conversely, lots for which specimens fail this test are to be rejected.
 - 5. Mark the material permanently so that the material certification can be verified after installation. Provide documentation that allows traceability of each piece of metal to the certification heat run number of the parent material.

2.4 ACCESSORY HARDWARE

- A. Instrument Test Holes: To suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments, and length to suit duct insulation thickness.
- B. Flexible Duct Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action, in sizes **3 to 18 inches (75 to 450 mm)** to suit duct size.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that openings for the installation of the duct system are of the size and in the location shown on drawings, that openings are clear of obstructions that might interfere with the installation of the ductwork or accessories, and no other interferences exist in the routing of ductwork. Notify the CM of conflicts. The CM will review to determine the appropriate resolution.

3.2 INSTALLATION/APPLICATION/ERECTION

- A. For static pressure of 10 inches WG or less, install and support ductwork in accordance with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for metal ducts. Angle rings, full bands, and bar saddle supports may be used to support the ductwork.
- B. For static pressure greater than 10 inches WG, install and support ductwork, fittings, and other components in accordance with SMACNA, rectangular Industrial Duct Construction Standards and SMACNA, Round Industrial Duct Construction Standards, as appropriate.
- C. Install flexible connections as close as possible to the equipment being isolated.
- D. Install rectangular and round ductwork instrument test ports in the general locations shown on drawings either on top, or sides (not bottom) of the duct to permit insertion of a pitot tube

across the entire duct section without interferences external to the duct. Clear opening through the duct wall to be equal to the port inside diameter.

- E. Install duct access panels on side of duct where adequate clearance is available to allow access to interior of ducts for cleaning, inspecting, adjusting, and maintaining the various accessories.
- F. Onsite welding activities are to be in accordance with Section 18100, "General Welding Requirements". And related sub-sections.
- G. Label access doors according to Division 15, Section 15074, "Identification and Labeling."

3.3 FIELD QUALITY CONTROL

- A. Weld inspection.
 - 1. Weld examinations: Examine welds per Section 18100.
- B. Ductwork Leakage Test:
 - 1. Leak-test the ductwork system as follows: The maximum leak rate to be in accordance with Table B-3 of Appendix B of ANSI/ASME N509. The ductwork shall be an Engineered Safety Feature Unit, Leakage Class 1.
 - 2. Perform duct leakage testing in accordance with ANSI/ASTM N510 using either the Direct Measurement Method or the Pressure Decay Method.
 - 3. The ductwork leakage test report to be in accordance with ANSI/ASME N510.
 - 4. If the ductwork fails to pass the leakage test, repair it to bring it into compliance and re-test it until acceptable leakage is demonstrated.
 - 5. Notify CM for inspection prior to concealment of work.
- C. After the ductwork system is installed, verify by inspection and by documents as follows:
 - 1. Dampers are installed in the proper configuration and location shown on drawings.
 - 2. Instrument test ports are installed at the correct position.
 - 3. Duct interiors are free of construction debris.
 - 4. Leakage Test reports are completed.

Table 15898-1		RECTANGULAR DUCT METAL GAGE AND REINFORCEMENT								
		Greatest Duct Width, Inches								
Pressure Class in. W.G. (positive or negative)	Sheet Metal Gage	Maximum Stiffener Spacing ft	thru 12	13 thru 24	25 thru 36	37 thru 48	49 thru 60	61 thru 72	73 thru 84	85 thru 96
			Acceptable Stiffener Angle Type							
2	16	6	R2	R2	R2	R3	R4	R4	R5	R6
	14	7	R2	R2	R2	R3	R4	R5	R6	R7
4	16	5	R2	R2	R2	R3	R4	R5	R6	R7
	14	6	R2	R2	R2	R3	R4	R6	R7	R8
6	16	4	R2	R2	R2	R3	R4	R6	R7	R8
	14	5	R2	R2	R3	R4	R5	R6	R7	R8
	12	7	R2	R2	R3	R5	R6	R7	R8	R9
8	16	3	R2	R2	R2	R3	R4	R5	R6	R7
	14	4	R2	R2	R3	R4	R5	R6	R7	R8
	12	6	R2	R2	R3	R5	R6	R7	R8	R10
10	14	3	R2	R2	R3	R4	R5	R6	R7	R8
	12	5	R2	R2	R3	R5	R6	R7	R9	R10
	11	6	R2	R2	R4	R5	R7	R8	R9	R11
12	14	3	R2	R2	R3	R4	R5	R6	R7	R8
	12	4	R2	R2	R3	R5	R6	R7	R8	R9
	11	5	R2	R2	R4	R5	R7	R8	R9	R11
16	12	3	R2	R2	R3	R5	R6	R7	R8	R9
	10	4	R2	R2	R4	R5	R7	R8	R9	R10
	3/16	6	R2	R3	R5	R7	R8	R9	R10	R11
20	11	3	R2	R2	R4	R5	R6	R8	R9	R10
	10	3	R2	R3	R4	R5	R6	R8	R9	R10
	9	4	R2	R3	R4	R6	R7	R9	R10	R11
	3/16	5	R2	R3	R5	R7	R8	R9	R10	R11

Table 15898-1 (cont)		STIFFENER ANGLE DIMENSIONS			
Type	Dimensions (in.)	Type	Dimensions (in.)	Type	Dimensions (in.)
R2	1-1/2 x 1-1/2 x 1/8	R6	2-1/2 x 2-1/2 x 1/4	R10	4 x 4 x 5/16
R3	1-1/2 x 1-1/2 x 1/4	R7	2-1/2 x 2-1/2 x 3/8	R11	4 x 3-1/2 x 1/2
R4	2 x 2 x 3/16	R8	2 x 2 x 3/8		
R5	2 x 2 x 5/16	R9	3 x 3 x 1/2		

Table 15898-2			ROUND DUCT METAL GAGE AND REINFORCEMENT									
			Duct Diameter, Inches									
Duct Pressure in. W.G.	Sheet Metal Gage	Minimum Stiffener Angle Type	thru 12	13 thru 18	19 thru 24	25 thru 30	31 thru 36	37 thru 42	43 thru 48	49 thru 54	55 thru 60	
			Maximum Stiffener Spacing (ft)									
(-)2	14	B	NR	NR	20	17	14	10	6			
	12	C					20	18	16	14	12	
	11	D							20	18	16	14
	10	E	DUCT IN THIS RANGE IS						20	18	17	16
	3/16	G	UNACCEPTABLE								20	20
(-)4	16	A	NR	NR	18	14	8	6	NOT ACCEPTABLE			
	14	B					20	18	14	12	10	
	12	E						20	18	17	15	13
	11	E	DUCT IN THIS RANGE IS					20	18	17	16	
	3/16	None	UNACCEPTABLE								20	20
(-)6	14	B	NR	20	15	9	6	4	NOT ACCEPTABLE			
	12	D	NR	NR	20	20	17	13	11	8		
	11	E				NR	20	20	18	16	14	12
	10	F	DUCT IN THIS RANGE IS				20	20	18	16	14	
	3/16	G	UNACCEPTABLE								20	18
(-)8	14	B	NR	18	12	7	4	NOT ACCEPTABLE				
	12	E		NR	20	18	14	11	8			
	11	F	DUCT IN THIS RANGE IS				20	18	16	14	12	10
	10	F	UNACCEPTABLE				20	18	16	14	12	
No. of 1-in. Welds			None	9	10	11	12	13	14	16	18	

Table 15898-2 (cont)			ROUND DUCT METAL GAGE AND REINFORCEMENT									
			Duct Diameter, Inches									
Duct Pressure in. W.G.	Sheet Metal Gage	Minimum Stiffener Angle Type	thru 12	13 thru 18	19 thru 24	25 thru 30	31 thru 36	37 thru 42	43 thru 48	49 thru 54	55 thru 60	
			Maximum Stiffener Spacing (ft)									
(-)10	14	C	NR	16	10	6	4	NOT ACCEPTABLE				
	12	E	DUCT IN THIS RANGE IS UNACCEPTABLE	NR	18	16	13	10	6			
	11	F		20			18	15	12	10	8	
	10	G		20			17	16	14	10		
	3/16	H		20			20	18	16			
(-)12	14	C	NR	13	8	4	NOT ACCEPTABLE					
	12	E	DUCT IN THIS RANGE IS UNACCEPTABLE	NR	17	14	11	8				
	11	F		20			17	14	11	8	6	
	10	G		18			16	14	12	10		
	3/16	H		20			20	18	16			
(-)16	12	F	NR	20	14	11	8	4	NOT ACCEPTABLE			
	11	G	DUCT IN THIS RANGE IS UNACCEPTABLE	NR	20	16	12	8	5			
	10	H		18			16	14	11	9	7	
	3/16	J		20			18	16	14			
	1/4	K		20			18	16				
(-)20	12	F	NR	16	11	8	5	NOT ACCEPTABLE				
	11	G	NR	20	18	14	10	6	4			
	10	H	18			15	12	9	6			
	3/16	J	20			18	16	14	12			
	1/4	K	20			18	16	14				
No. of 1-in. Welds			None	9	10	11	12	13	14	16	18	

Table 15898-2 (cont)		STIFFENER ANGLE DIMENSIONS			
Type	Dimensions (in.)	Type	Dimensions (in.)	Type	Dimensions (in.)
A	1 x 1 x 1/8	E	2 x 2 x 3/16	I	3 x 3 x 5/16
B	1-1/4 x 1-1/4 x 3/16	F	2 x 2 x 1/4	J	2-1/2 x 2-1/2 x 1/2
C	1-1/2 x 1-1/2 x 3/16	G	2-1/2 x 2-1/2 x 1/4	K	3 x 3 x 1/2
D	1-1/2 x 1-1/2 x 1/4	H	2-1/2 x 2-1/2 x 5/16		

END OF SECTION 15898